

DRAFT ECONOMICS APPENDIX

WILLAPA BAY ECOSYSTEM RESTORATION PROJECT

Economic Evaluation of Alternatives. The economic evaluation of the Willapa Bay ecosystem restoration project was performed in accordance with ER 1105-2-100 dated 22 April 2000. ER 1105-2-100 directs that single purpose ecosystem restoration plans shall be formulated and evaluated in terms of their net contributions to increases in ecosystem value, expressed in *non-monetary units*. A plan that reasonably maximizes ecosystem restoration outputs compared to costs, consistent with the Federal objective, shall be selected. The selected plan must be shown to be cost effective and justified to achieve the desired level of output. This plan shall be identified as the National Ecosystem Restoration (NER) Plan.

All Corps projects except ecosystem restoration projects determine a monetary value for the project benefits. The National Economic Development (NED) Plan is the plan with the maximum difference between benefits and costs expressed in monetary terms. The Corps requirement to express ecosystem value in non-monetary units is recognition of difficulties and controversies involved in determining monetary values for ecosystem outputs; however, this means that costs and benefits are in dissimilar units and therefore the difference, or net benefits, cannot be mathematically maximized. Determining an NER plan relies on judgment and is a necessarily subjective process.

NER Plans consist of combinations of management measures and other alternatives formulated during the plan formulation process to achieve the project objectives. Sometimes the possible combinations can be extremely large. The Corps uses Cost Effectiveness and Incremental Cost Analysis, described in the Institute for Water Resources (IWR) Report #95-R-1 (May 1995) to systematically screen plans and alternatives.

CEA/ICA Procedure

There are nine steps to accomplishing CEA/ICA. Step 1 is to define the outputs and costs of each management measure or alternative. Step 2 is to identify the combinability and dependency relationships of the measures and. Some measures depend on the implementation of other measures, some measures cannot be combined with other measures, and some measures are independent of other measures. Step 3 is to derive all the possible combinations, or plans, and calculate the costs and outputs of each plan. Once all possible plans are identified and the plans that are inefficient in production are identified and screened out in step 4. These plans are defined as plans where the same level of output can be provided at a lesser cost by another plan. The purpose of step 5 is to screen out of the remaining plans those that are ineffective in production. These plans are defined as plans that produce less output at an equal or greater cost.

Incremental cost analysis is performed on the remaining plans in steps 6 through 9. Step 6 calculates incremental cost, incremental output, and incremental cost per unit of

advancing to each successive cost effective output level. If the incremental cost per unit continuously increases across all of the cost effective plans then step 7 through 9 are not necessary, however this is not likely to occur. Step 7 differs from step 6 in that in this procedure we want to calculate the change in cost and the change in output from implementing each plan instead of the no-action plan. The plan with the least average incremental cost per unit of output other than the no action plan is the “best deal” or “Best Buy” for production of output beyond the no-action plan. Plans that produce lower levels of output are screened out from further steps, in reality though those plans that are screened out during this step may be implemented if properly justified since they do meet the requirement of being cost effective. Step 8 repeats the process of step 7, however the changes are calculated with respect to the “Best Buy” Plan identified in Step 7. The plan that has the least incremental cost per incremental unit of output is selected as the next “Best Buy” plan and again all plans with less output are eliminated from further analysis. This process is reiterated until the incremental unit cost of the last remaining plan is calculated. The number of iterations is dependent on the number of plans and the respective cost and output data. Step 9 is to tabulate and display the results.

The purpose of steps 7 and 8 is not to eliminate plans from the possibility of being selected, but to identify plans and their corresponding level of output where there is a marked increase in production costs. There is no decision rule for selecting the level of output as there is in traditional NED analysis, but helps inform the process and focus on asking and answering the question: “Is the additional output “worth it”?”

This process can be long and involved if there are very many measures or alternatives, but it is an efficient rational and objective process. A software application developed by the Institute for Water Resources called IWR Plan was used to analyze the management measures for Willapa Bay project that is a very useful and efficient tool for this process. Following is a description of the variables used to conduct this analysis with IWR Plan and the consequent results.

Defining the Management Measures

Detailed descriptions of the measures are in section 6.2 Proposed Restoration Measures. In addition to the do nothing alternative, there are seven individual Management measures, which are discussed below.

Outputs: The ecosystem outputs for the Willapa Bay Restoration projects will be quantified using a weighted point system that will represent expected average annual outputs. Points are calculated based on the weighted sum of 0.5 points per acre inundated and 0.25 points per lineal foot of wetted edge created. Outputs are assumed to be additive when combined with another measure.

Costs: Detailed Cost Estimates are provided in Appendix B. LERR&R costs are documented in Appendix E. The costs of the individual Management measures are given here as First Costs from the Appendices (First Costs include Construction Costs, Supervision and Administrative Costs, Engineering and Design Costs, Escalation costs, Contingency Costs, Mob/Demob costs, traffic

control costs, and LERR&R.). These costs were converted to equivalent average annual costs for a 50-year project life at 5.875% average annual percentage rate. The expected average annual OMRR&R costs are also displayed. Total Equivalent Average Annual Costs are the sum of Equivalent Average Annual Costs and Average Annual OMRR&R. Costs are assumed to be additive when combined with another measure.

Measure 1 – Dike Removal. This measure consists of removing 11,000 linear feet of dike. The soil removed from the dike would be placed in a borrow ditch that runs along the upland side of the dike. This measure would also fill five drainage ditches to ensure drainage of tidal waters. There would also be construction of a 1,400 foot long cross dike to prevent inundation of neighboring properties. The material required to construct this dike would be imported. This measure would result in tidal flow inundating 250 acres of land and 1845 feet of wetted edge. The first costs including LERR&R are estimated to be \$1,537,847. OMRR&R is expected to average \$1500 annually for levy maintenance and up to \$7500 annually for Spartina control

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 8, Measure 9, Measure 10, and Measure 11.

May be combined with: Measure 2, Measure 3, Measure 4, Measure 5, Measure 6, and Measure 7.

Output:

Acres Inundated:	250 acres @ 0.5pts/acre = 125 points
Wetted Edge:	1845 feet @ 0.25pts/foot = 461.25 points
Total Weighted Points:	125 + 461.25 = 586 Weighted Points

Costs:

	<u>Measure 2</u>
Construction	\$1,007,586
Contingency	\$ 251,897
Escalation	\$ 86,490
PED	\$ 121,138
S&A	\$ 176,054
Mob/Demob	\$ 15,277
Traffic Control	\$ 13,756
Total First Costs	\$1,672,197
Real Estate	\$ 185,000
<u>Real Estate Contingency</u>	<u>\$ 27,750</u>
Total First Costs Plus LER	\$1,710,724

<u>Equivalent Average Annual Costs</u>	
First Costs Plus LER	\$ 106,647
OMRR&R	
Spartina Control	\$ 7,500
Levy Maintenance	\$ 1,500
Total Equivalent Average Annual Cost	\$ 115,647

Measure 2 – Excavation of Tidal Channel #5. This measure consists of excavating one 2000-foot long primary tidal channel and “nicking” of two secondary tidal channels. The primary channel will follow the alignment of one of eight remnant channels and has been titled channel #5. The initial length of the secondary channels are 139 feet and 171 feet creating 8156 feet of additional wetted edge and are expected to increase in length over time due to tidal action. The first costs are estimated to be \$104,821 and LERR&R is estimated at \$0.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 3, Measure 4, Measure 5, Measure 6, and Measure 7.

Output:

Acres Inundated:	0 acres @ 0.5pts/acre = 0 points
Wetted Edge:	8156 feet x 0.25pts/foot = 2039 points
Total Weighted Points:	0 + 2039 = 2039 Weighted Points

Costs:

	<u>Measure 2</u>
Construction	\$ 64,276
Contingency	\$ 16,069
Escalation	\$ 5,517
PED	\$ 7,728
S&A	\$ 11,231
Mob/Demob	\$ -
Traffic Control	\$ -
Total First Costs	\$ 104,821
Real Estate	\$ -
Real Estate Contingency	\$ -
Total First Costs Plus LER	\$ 104,821

<u>Equivalent Average Annual Costs</u>	
First Costs Plus LER	\$ 6,535
OMRR&R	

Spartina Control	\$	-
Levy Maintenance	\$	-
Total Equivalent Average Annual Cost	\$	6,535

Measure 3 – Excavation of Tidal Channel #1. This measure would create a tidal channel 1,270 feet long and would follow the alignment of the original channel #1 and is expected to create 2831 additional feet of wetted edge. The first costs are estimated to be \$74,542 and LERR&R is estimated at \$0.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 2, Measure 4, Measure 5, Measure 6, and Measure 7.

Output:

Acres Inundated:	0 acres @ 0.5pts/acre = 0 points
Wetted Edge:	2831 feet x 0.25pts/foot = 707.75 points
Total Weighted Points:	0 + 707.75 = 707.75 Weighted Points

Costs:

	<u>Measure 3</u>
Construction	\$ 45,709
Contingency	\$ 11,427
Escalation	\$ 3,924
PED	\$ 5,495
S&A	\$ 7,987
Mob/Demob	\$ -
<u>Traffic Control</u>	\$ -
Total First Costs	\$ 74,542
Real Estate	\$ -
<u>Real Estate Contingency</u>	\$ -
Total First Costs Plus LER	\$ 74,542

Equivalent Average Annual Costs

First Costs Plus LER	\$ 4,647
OMRR&R	
Spartina Control	\$ -
Levy Maintenance	\$ -
Total Equivalent Average Annual Cost	\$ 4,647

Measure 4 –Excavation of Tidal Channel #2. A tidal channel that is 1,570 feet in length would be constructed that follows the alignment of channel #2 and is expected to create an additional 3926 feet of wetted edge. The first costs are estimated to be \$52,932 and LERR&R is estimated at \$0.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 2, Measure 3, Measure 5, Measure 6, and Measure 7.

Output:

Acres Inundated:	0 acres @ 0.5pts/acre = 0 points
Wetted Edge:	2831 feet x 0.25pts/foot = 981.5 points
Total Weighted Points:	0 + 981.5 = 981.5 Weighted Points

Costs:

	<u>Measure 4</u>
Construction	\$ 32,458
Contingency	\$ 8,115
Escalation	\$ 2,786
PED	\$ 3,902
S&A	\$ 5,671
Mob/Demob	\$ -
Traffic Control	\$ -
Total First Costs	\$ 52,932
Real Estate	\$ -
Real Estate Contingency	\$ -
Total First Costs Plus LER	\$ 52,932

Equivalent Average Annual Costs

First Costs Plus LER	\$ 3,300
OMRR&R	
Spartina Control	\$ -
Levy Maintenance	\$ -
Total Equivalent Average Annual Cost	\$ 3,300

Measure 5 - Excavation of Tidal Channel #7. This measure consists of constructing a primary tidal channel 1,970 feet in length with a secondary channel about 100 feet in length and is expected to create an additional 5095 feet of wetted edge. The first costs are estimated to be \$8,134 and LERR&R is estimated at \$0.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 2, Measure 3, Measure 4, Measure 6, and Measure 7.

Output:

Acres Inundated:	0 acres @ 0.5pts/acre = 0 points
Wetted Edge:	5095 feet x 0.25pts/foot = 1273.75 points
Total Weighted Points:	0 + 1273.75 = 1273.75 Weighted Points

Costs:

	<u>Measure 5</u>
Construction	\$ 4,988
Contingency	\$ 1,247
Escalation	\$ 428
PED	\$ 600
S&A	\$ 872
Mob/Demob	\$ -
Traffic Control	\$ -
Total First Costs	\$ 8,134
Real Estate	\$ -
Real Estate Contingency	\$ -
Total First Costs Plus LER	\$ 8,134

	<u>Equivalent Average Annual Costs</u>
First Costs Plus LER	\$ 3,300
OMRR&R	
Spartina Control	\$ -
Levy Maintenance	\$ -
Total Equivalent Average Annual Cost	\$ 507

Measure 6 – Excavation of Tidal Channel #8. A primary channel that is 1,700 feet long and a secondary channel 780 feet in length would be constructed. An additional 5728 feet of wetted edge are expected to be created. The first costs of this measure are estimated at \$45,494 and LERR&R is estimated at \$0.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 2, Measure 3, Measure 4, Measure 5, and Measure 7.

Output:

Acres Inundated:	0 acres @ 0.5pts/acre = 0 points
Wetted Edge:	5728 feet x 0.25pts/foot = 1432 points
Total Weighted Points:	0 + 1432 = 1432 Weighted Points

Costs:

	<u>Measure 6</u>
Construction	\$ 27,897
Contingency	\$ 6,974
Escalation	\$ 2,395
PED	\$ 3,354
S&A	\$ 4,874
Mob/Demob	\$ -
Traffic Control	\$ -
Total First Costs	\$ 45,494
Real Estate	\$ -
Real Estate Contingency	\$ -
Total First Costs Plus LER	\$ 45,494

Equivalent Average Annual Costs

First Costs Plus LER	\$ 2,836
OMRR&R	
Spartina Control	\$ -
Levy Maintenance	\$ -
Total Equivalent Average Annual Cost	\$ 2,836

Measure 7 - Excavation of Tidal Channel #5a. This project is comprised of implementing a 70-foot wide breach through the roadbed of Highway 101 to permit tidal flow to the landward side of highway 101, which results in the inundation of 107 acres. An additional cross dike to prevent flooding of neighboring properties and Highway 101 would also be constructed. If this Measure is implemented Washington State Department of Transportation (WSDOT) will construct a bridge over the 70 foot breached area.

Although the Federal Government will not directly cost share in construction of the bridge implementing this measure would cause national and regional economic resources to be used to construct the bridge. These resources have other uses, or opportunity costs, which are approximated by the estimated cost of the bridge. For example, instead of building this bridge to acquire additional estuarine environment, the labor and materials could be used to make other transportation infrastructure improvements vital to the local,

regional or national economy. Thus the costs of constructing the bridge are relevant costs for evaluating and selecting an NER Plan, however the federal government will not share in the costs of the bridge.

The first costs of this measure including the WSDOT supplied cost estimate for the bridge are estimated at \$1,054,451, of which \$994,783 are for the bridge, and LERR&R is estimated to be \$67,000. the output is 107 additional acres inundated and 12,381 feet of additional edge.

Dependence and combinability relationship with other measures:

Cannot be combined with: No-Action Plan

Is Dependent on or must be combined with: Measure 1

May be combined with: Measure 2, Measure 3, Measure 4, Measure 5, and Measure 6.

Output:

Acres Inundated:	107 acres @ 0.5pts/acre = 53.5 points
Wetted Edge:	12,381 feet x 0.25pts/foot = 3095.25 points
Total Weighted Points:	53.5 + 3095.25 = 3148.75 Weighted Points

Costs:

	Measure 7 (w/bridge)	Measure 7 (wo/bridge)
Construction	\$ 646,588	\$ 36,588
Contingency	\$ 161,647	\$ 9,147
Escalation	\$ 55,502	\$ 3,141
PED	\$ 77,737	\$ 4,399
S&A	\$ 112,977	\$ 6,393
Mob/Demob	\$ -	\$ -
Traffic Control	\$ -	\$ -
Total First Costs	\$1,054,451	\$ 59,667
Real Estate	\$ -	\$ 67,000
Real Estate Contingency	\$ -	\$ 10,050
Total First Costs Plus LER	\$1,054,451	\$ 69,717

Equivalent Average Annual Costs

First Costs Plus LER	\$ 65,734	\$ 4,346
OMRR&R		
Spartina Control	\$ 2,500	\$ 2,500
Levy Maintenance	\$ 1,500	\$ 1,500
Total Equivalent Average Annual Cost	\$ 69,734	\$ 8,346

Summary of Expected Costs and Benefits.

Table ____ summarizes the expected costs and outputs for each measure. The costs and outputs and the combinability and dependence relationships were entered into IWR Plan application program designed by IWR (Institute for Water Resources) for conducting CEA/ICA.

Table E-1. ECOSYSTEM RESTORATION EXPECTED COSTS AND OUTPUTS

Ecosystem Project Management Measure	Total Equivalent Average Annual Costs	Outputs (Weighted Points)	<u>May Not Be Combined With</u>	<u>Must Be Combined With</u>	<u>May Be Combined With</u>
Measure 0 (Do Nothing)	\$ -	0	Any Other	No Others	No Others
Measure 1 (M1)	\$ 115,647	586	M0	M8, M10, M11	M2, M3, M4, M5, M6, M7
Measure 2 (M2)	\$ 6,535	2039	M0	M1	M3, M4, M5, M6, M7
Measure 3 (M3)	\$ 4,647	708	M0	M1	M2, M4, M5, M6, M7
Measure 4 (M4)	\$ 3,300	982	M0	M1	M2, M3, M5, M6, M7
Measure 5 (M5)	\$ 507	1274	M0	M1	M2, M3, M4, M6, M7
Measure 6 (M6)	\$ 2,836	1432	M0	M1	M2, M3, M4, M5, M7
Measure 7 (M7)	\$ 69,734	3149	M0	M1	M2, M3, M4, M5, M6

IWR Plan Results

The management measure Total Equivalent Average Costs, Outputs, and their relationships information was entered into IWR. IWR Plan derived all possible combinations of the management measures. Using the 8 identified possible management measures, including the No-Action measure, IWR Plan formulated all possible combinations of the identified management measures for restoring estuarine habitat resulting in 128 possible combinations, or Plans, and 49 actual Plans.

Cost Effectiveness Analysis (CEA)

The objective of CEA analysis is to identify and eliminate from further consideration Plans that are not cost effective. Cost effective plans produce the same output as other combinations for less cost (production efficient) or produce more output than others at the same or less cost (production effective). IWR Plan identified 13 Cost Effective plans of the 65 actual plans. Table E-2 displays the cost-effective plans and the measures included in each plan with their average annual outputs in Total Weighted Points and Total Equivalent Average Annual Cost. Incremental Cost analysis, (steps 6 through 9) is performed on these remaining 14 Plans.

TABLE E-2 COST EFFECTIVE PLANS

Plan	Measures Implemented	Wtd-Points	EAAC
1	M0	0	\$ -
2	M1	586	\$ 115,647
3	M1 & M5	1860	\$ 116,154
4	M1 & M6	2018	\$ 118,483
5	M1, M5, & M6	3292	\$ 118,990
6	M1, M4, M5, & M6	4274	\$ 122,290
7	M1, M2, M5, & M6	5331	\$ 125,525
8	M1, M2, M4, M5, & M6	6313	\$ 128,825
9	M1, M2, M3, M4, M5, & M6	7021	\$ 133,472
10	M1, M4, M5, M6 & M7	7423	\$ 192,024
11	M1, M2, M5, M6 & M7	8480	\$ 195,259
12	M1, M2, M4, M5, M6 & M7	9462	\$ 198,559
13	M1, M2, M3, M4, M5, M6 & M7	10170	\$ 203,206

Incremental Cost Analyses (ICA)

The NER Plan must be shown to be cost effective and justified to achieve the desired level of output. Cost Effectiveness Analysis performed by IWR Plan determined that there are 13 cost effective plans. IWR Plan automatically performs Incremental Cost Analysis on the cost effective plans.

Sorted by increasing levels of output Table E-3 displays the results of the Incremental Analysis with Total Weighted Points, Incremental Points, Average Equivalent Annual Cost per Weighted point (this is the same as Average Cost per Point in this case), Incremental Cost, and Incremental Cost per Incremental Point for each of the 13 Cost Effective Plans. Plans 1, 9, and 13 are the “Best Buy” Plans.

TABLE E-3. INCREMENTAL COST PER INCREMENTAL OUTPUT

Plan	EAAC	Wtd-Points	Average Cost Per Wtd Point	Incremental Points	Incremental Cost	Incremental Cost per Incremental Points
1	\$ -	0	\$ -	0	\$ -	0
2	\$ 115,647	586	\$ 197.35	586	\$ 115,647	\$ 197.35
3	\$ 116,154	1860	\$ 62.45	1860	\$ 116,154	\$ 62.45
4	\$ 118,483	2018	\$ 58.71	2018	\$ 118,483	\$ 58.71
5	\$ 118,990	3292	\$ 36.15	3292	\$ 118,990	\$ 36.15
6	\$ 122,290	4274	\$ 28.61	4274	\$ 122,290	\$ 28.61
7	\$ 125,525	5331	\$ 23.55	5331	\$ 125,525	\$ 23.55
8	\$ 128,825	6313	\$ 20.41	6313	\$ 128,825	\$ 20.41
9	\$ 133,472	7021	\$ 19.01	7021	\$ 133,472	\$ 19.01
10	\$ 192,024	7423	\$ 25.87	402	\$ 58,552	\$ 145.65

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11	\$ 195,259	8480	\$ 23.03	1459	\$ 61,787	\$ 42.35
12	\$ 198,559	9462	\$ 20.98	2441	\$ 65,087	\$ 26.66
13	\$ 203,206	10170	\$ 19.98	3149	\$ 69,734	\$ 22.14

“Best Buy” Plan 9 would increase total ecosystem outputs by 250 acres and 27,584 feet of wetted edge for an equivalent average annual cost of \$133,472, which based on the weighted point scoring, is \$19.01 per point. “Best Buy” Plan 14 adds another 107 acres and an additional 12,381 feet of wetted edge, which increases production costs to \$22.14 or an additional \$3.13 per incremental point of output, while the average cost per point rises to \$19.98.

Graph 1 displays the above data in a graphical format. If the weighted points are reasonable indicators of the increase in ecosystem output quantity and quality, then this graph indicates that the Willapa Bay Estuarine Restoration Project is very efficient at producing the desired ecosystem outputs.

Graph 1

